International Journal for Research and Development in Engineering (IJRDE)

www.ijrde.com Vol.1: Issue.3, February-March 2013 pp- 9-17

Analysis of the Mediterranean States' Power Markets in connection to DESERTEC

*Asad Waqar,
Lecturer, Electrical Engineering Depertment, COMSATS Institute of Information Technology
asad.waqar@ciitwah.edu.pk

Abstract—**The aim of this paper is to present a quick overview of the current situation and existing infrastructure of the power markets of the Mediterranean states in connection to DESERTEC** [1]**. The author has investigated and comprehensively explained the power markets with respect to their functional structures, extent of market liberalization, development of peak load demand, development of installed capacity, development in energy generation, primary energy sources and electrical interconnections. Further energy consumption and peak load demand have been extrapolated to determine the possible energy needs till the year 2050. The scope of this investigation assessment is limited to Algeria, Morocco, Tunisia, Libya, Egypt, Jordan and Turkey.**

Keywords- ***DESERTEC ; Power Markets; Peak Load Demand; Installed Capacity; Energy Generated; Primary Energy Sources; Transmission Grid; Electrical Interconnections***

I. INTRODUCTION

It is human nature that always keeps him in motion to seek improvement in every aspect of life. As the World's population has grown the demand for energy consumption has also increased. Since a century conventional energy sources have been in use to meet the energy needs. But with the passage of time their reserves are declining. So human efforts are continued to explore more fossil fuel reserves as well as seek opportunities in renewable energy sources (RES). Fossil fuel power generation has the biggest threat of CO_2 emissions to the World's atmosphere. Therefore more and more efforts are carried out to generate energy from RES.

Green energy from African Sahara deserts is the most weighted chapter in this course. This concept is well known as DESERTEC. DESERTEC is a concept of generating solar and wind energy from African deserts and transporting it to Europe via a super-grid of HVDC transmission system. DESERTEC was developed in 2003 by Trans-Mediterranean Renewable Energy Corporation (TREC). In 2009 DESERTEC foundation in collaboration with 12 private companies launched the concept of DESERTEC Industrial Initiative (DII). DII has the responsibility to convert the idea to reality. Europe-Middle East and North Africa (EU-MENA) is the region where this concept will be implemented. The DESERTEC's plan seeks a generation capacity of 100 GW from concentrated solar power plants (CSPs) and 500 GW from other RES to be installed by the year 2050. The capacity will fulfill the energy needs of MENA region. Further 15% of the Europe's energy needs will be fulfilled using this capacity [14].

II. INVESTIGATION AND ANALYSIS

The power markets of the countries under investigation have been assessed in terms of their

- market infrastructure, extent of liberalization of power markets, key players associated with energy particularly with electricity business, share of public and private installed capacities, share of public and private generated energies
- development of peak load demand
- development of the installed capacity, development in the energy generation
- primary energy sources
- lengths of transmission networks, electrical interconnections and cross border energies exchanged

This investigation was focused towards the power markets of Mediterranean states starting from Algeria, Morocco, Tunisia, Libya, Egypt, Jordan and Turkey.

Algeria

Since nationalization in 1947, state owned power company SONELGAZ had the monopoly for generation, transmission and distribution of electricity. In February 2002 a new law to reform the power market privatized SONELGAZ. However the state still owns maximum shares of SONELGAZ. This reform also created Electricity & Gas Regulatory Authority (CREG) to manage and control the newly reformed power market and to ensure non-discriminatory access to this sector. Following this

new reform, SONELGAZ along with Oil Development Company (SONATRACH) started a joint venture called Algerian Energy Company (AEC). Strategy behind this joint venture was to attract the foreign investors. Algerian law was requiring that foreign investors should make joint ventures with AEC and in return AEC would buy all the generated energy. In July 2002 SONELGAZ along with SONATRACH had a joint venture called New Energy Algeria (NEAL) with primary focus to look for opportunities in RES. Since January 2009 SONELGAZ is operating as a holding company with 33 subsidiaries and 6 direct ventures. Out of these 39 companies only 7 are directly engaged with electricity business [2] [15]. The structure Algerian power market is shown in figure 1a. The table I explains the abbreviations used in figure 1a.

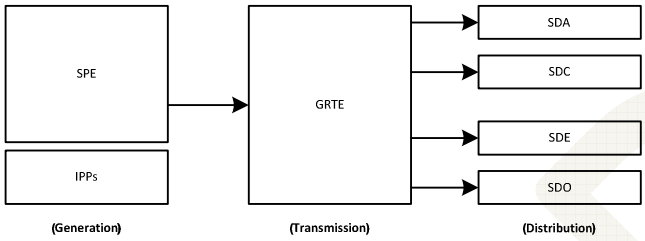

Fig. 1a Algeria-Structure of power market

TABLE I. ALGERIA-STRUCTURE OF POWER MARKET

Sr. No.	Company	
	Abbreviation	*Explanation*
1	SPE	Société algérienne de pr oduction de l'électricité
2	IPPs	Independent power producers
3	GRTE	Société algérienne de gestion du r éseau de transport de l'électricité
4	SDA	Société de distribution de l'électricité et du gaz d'Alger
5	SDC	Société de distr ibution de l 'électricité et du gaz du Centre
6	SDE	Société de distribution de l'électricité et du gaz de l'Est
7	SDO	Société de distr ibution de l 'électricité et du gaz de l'Ouest

The peak load demand in 2009 was 7.2 GW that is 5% increase from 2008. On the other hand the installed capacity in 2009 was 11.3 GW that is an increase of 33% from the year 2008. In 2009 the total energy demand was 33.9 TWh that is 3% increase from 2008. Similarly the energy generated in 2009 was 42.7 TWh that is 9% increase from previous year 2008. The time-series in figure 2a shows the development of installed capacity and peak load demand from 2003-2009. The time-series in figure 2b shows the development in energy generated and consumed from 2003-2009.

Thermal power sources contribute almost all of the energy supply supplemented by a small amount of hydro power. Natural gas is the main source of thermal power generation accounting for 97% of total generation. Figure 9a shows the share of energies generated by different types of power plants in 2009.

Algeria's installed capacity is shared by state owned generation (SPE) and independent power producers (IPPs). In 2009 SPE units generated 62% and IPPs generated 38% of total energy. Figure 9b shows the share of public and private installed capacities in 2009. Figure 9c shows the share of public and private generated energies in 2009.

According to SONELGAZ the length of its transmission system was 18000 km in 2009. Algeria has 400 kV, 220 kV, 150 kV, 90 kV and 60 kV lines in its transmission network. Algeria has electrical interconnections with Morocco and Tunisia. In 2009 Algeria exported 42.9 GWh to Morocco and imported 5.9 GWh from Tunisia.

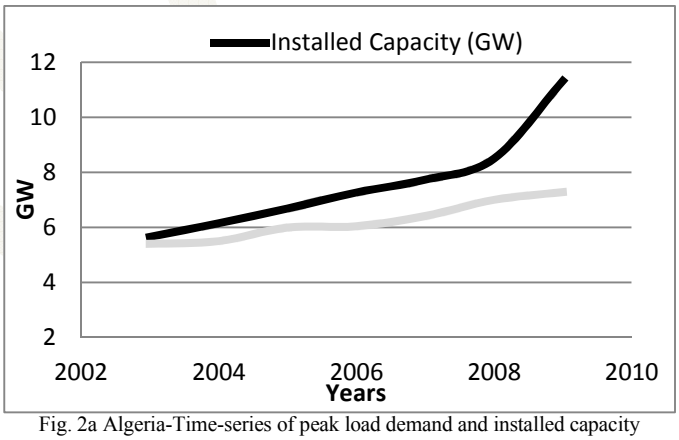

Fig. 2a Algeria-Time-series of peak load demand and installed capacity

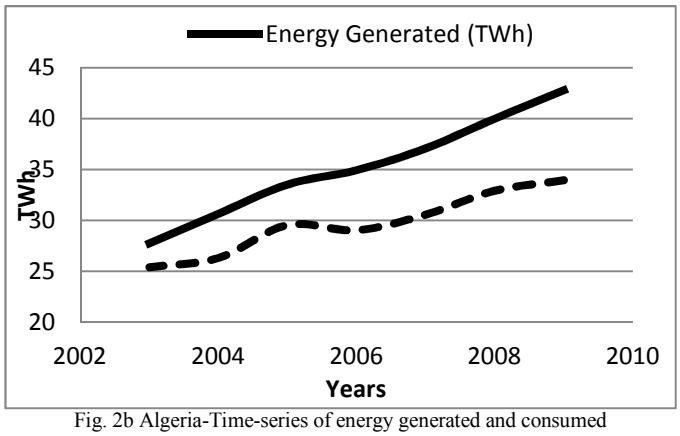

Fig. 2b Algeria-Time-series of energy generated and consumed

Morocco

Morocco's power market is controlled and operated by state owned Office National de l'Electricité (ONE). In order to reduce some financial burden and gain profitability, in 1995 government recognized to privatize ONE with an aim that till 2020 state will be owning only 40% shares of ONE. Initial step was to introduce private investment in power generation sector only. Up to date state still owns maximum shares of ONE.

Power generation is shared by ONE and Independent Power Producers (IPPs). IPPs include Morocco's largest installed capacity power plant named Jorf Lasfar Energy Company (JLEC). JLEC has an installed capacity of 1.32 GW. The transmission network is owned and operated by ONE. Power distribution is carried out along with 11 privately owned municipal utility companies. These distribution companies are covering 45% of overall distribution [3] [15]. The structure of Moroccan power market is shown in figure 1b.

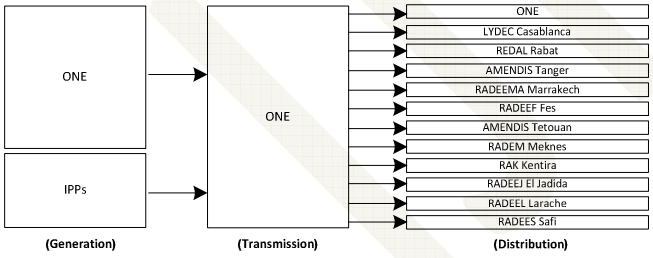

Fig. 1b Morocco-Structure of power market

The peak load demand in 2009 was 4.3 GW that is 4.6% increase from 2008. The installed capacity in 2009 was 6.13 GW that is 16% increase from 2008. The time-series in figure 3a shows the development of installed capacity and peak load demand from 2003-2009.

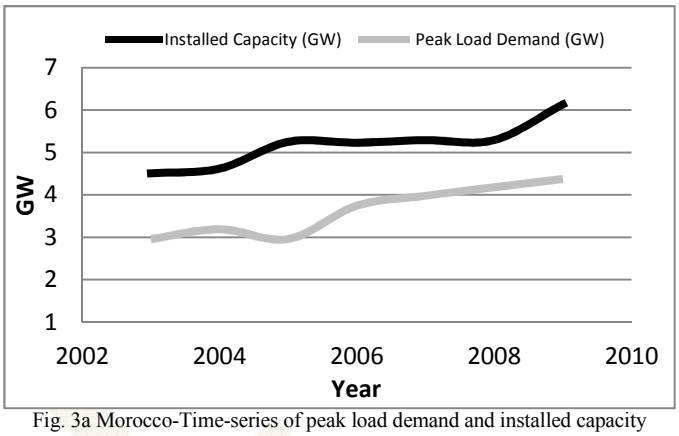

Fig. 3a Morocco-Time-series of peak load demand and installed capacity

In 2009 the total energy consumption was 23.9 TWh that is 3% increase from 2008. Similarly the total energy generated was 20.953 TWh that is 3.9% increase from 2008. The time-series in figure 3b shows the development of energy generated and consumed from 2003-2009.

Morocco's installed capacity consists of thermal, hydro and wind power plants. Coal is the major fuel for thermal power units. Figure 9a shows the share of energies generated by different types of power plants in 2009. In 2009 ONE's units generated 39% and IPPs generated 61% of total energy. Figure 9b shows the share of public and private installed capacities in 2009. Figure 9c shows the share of public and private generated energies in 2009.

Morocco's transmission system had a length of 20350 km in 2009. It is comprised of 400 kV, 225 kV, 150 kV and 60 kV transmission lines. Morocco is synchronously connected with Algeria and Spain. In 2009 Morocco has imported 4261.4 GWh of energy from Spain and exported 42.9 GWh to Algeria.

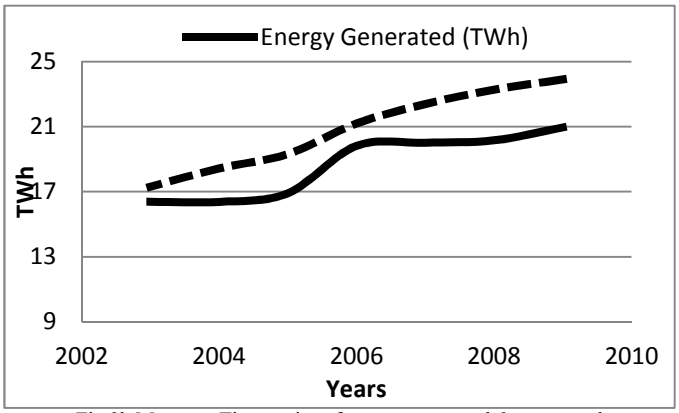

Fig 3b Morocco-Time-series of energy generated & consumed

Tunisia

Power market in Tunisia is controlled and operated by state owned company Société Tunisienne de l'Electricité et du Gaz

(STEG). In 1996 government withdrew STEG's monopoly for power generation to allow private investment in generation sector. However STEG will be responsible for transmission & distribution along with control of existing power generation plants. Independent power producers (IPPs) contribute to 14.3% of total installed capacity [4] [15]. The structure of Tunisian energy market is shown in figure 1c.

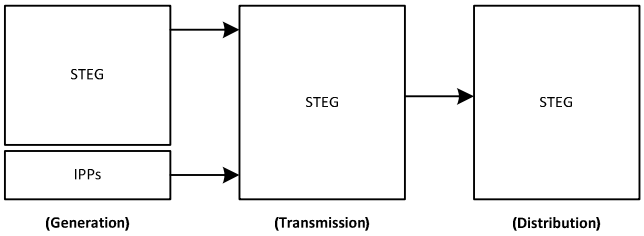

Fig 1c Tunisia-Structure of power market

The peak load demand in 2009 was 2.6 GW that is 7% increase from 2008. The installed capacity in 2009 was 3.47 GW that is 4.8% increase from 2008. The energy consumed in 2009 was 13.7 TWh that is 2.7% increase from 2008. The energy generated in 2009 was 14.14 TWh that is 2.8% increase from 2008. The time-series in figure 4a shows the development of installed capacity and peak load demand from 2003-2009. The time-series in figure 4b shows the development energy generated and consumed from 2003-2009.

Tunisia's installed capacity consists of thermal, hydro and wind power plants. Thermal units have 96% of total installed capacity. Figure 9a shows the share of energies generated by different types of power plants in 2009. In 2009 STEG contributed to 76% of total generated energy while rest was generated by IPPs. Figure 9b shows the share of public and private installed capacities in 2009. Figure 9c shows the share of public and private generated energies in 2009.

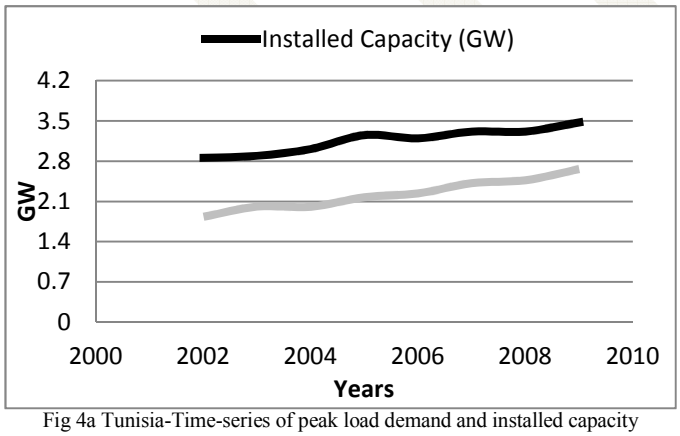

Fig 4a Tunisia-Time-series of peak load demand and installed capacity

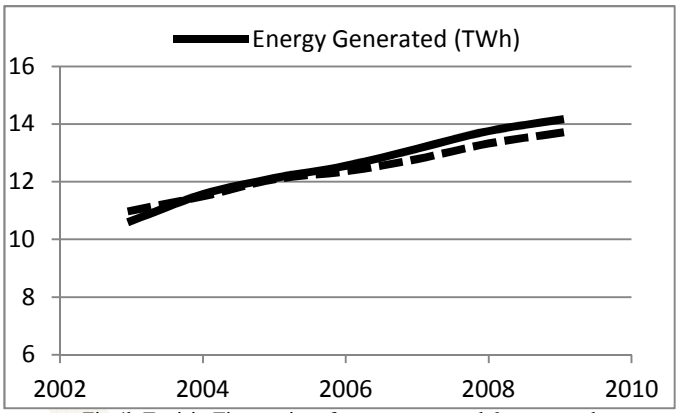

Fig 4b Tunisia-Time-series of energy generated & consumed

The Tunisian transmission system had a length of more than 5000 km in 2009. It is comprised of 225 kV, 150 kV and 90 kV transmission lines. Tunisia is connected to Europe through Morocco. Electrical interconnection to Libya is allowing the connection to Mashreq countries. In 2009 Tunisia exported 46 GWh to Libya and 5.9 GWh to Algeria.

Libya

Libya's power market is controlled and operated by General Electricity Company of Libya (GECOL). The GECOL is currently dominating the Libyan power sector in such a greater extent than almost any other state owned company in the World. Apart from controlling all levels of the power business (generation, transmission, distribution and revenue collection) it acts as the ministry of power within Libya's unique system of Government and also as a Regulator. With such extensive influence and authority, GECOL is expected to be reluctant to give up its dominating position. In a nutshell GECOL is the only player in the market dealing with power and energy business [5] [15]. The structure of Libyan power market structure is shown in figure 1d.

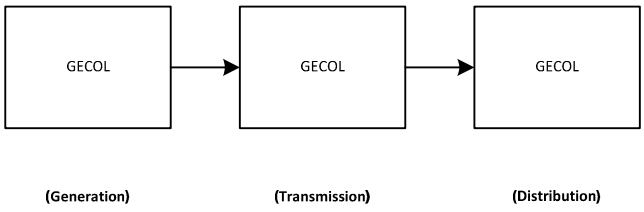

Fig 1d Libya-Structure of power market

The peak load demand in 2009 was 5.2 GW that is 11% increase from 2008. The installed capacity in 2009 was 6.7 GW that is 9% increase from 2008.The energy consumed in 2009 was 26.1 TWh that is 8.3% increase from 2008. The energy generated in 2009 was 30.3 TWh that is 5.9% increase from 2008. The time-series in figure 5a shows the development of installed capacity and peak load demand from 2003-2009. The

time-series in figure 5b shows the development in energy generated and consumed from 2003-2009.

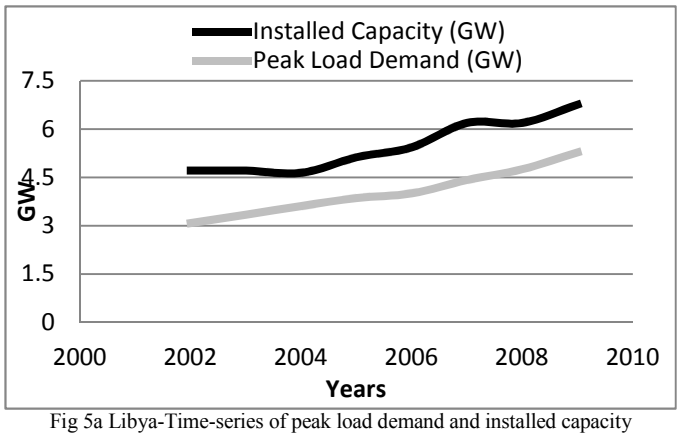

Fig 5a Libya-Time-series of peak load demand and installed capacity

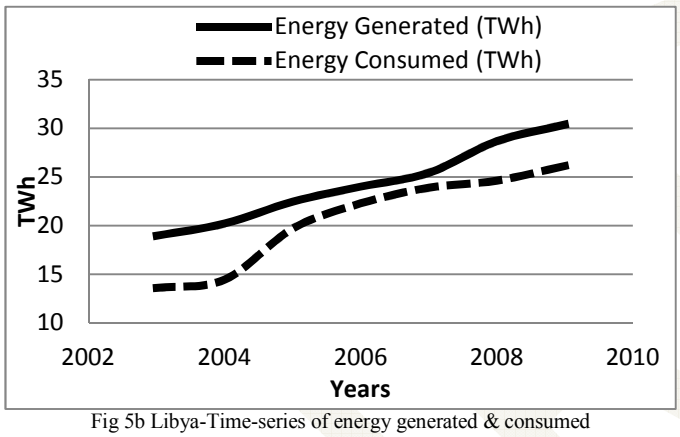

Fig 5b Libya-Time-series of energy generated & consumed

Libya's installed capacity consists of only thermal power plants. Before 2004 most of thermal power plants were oil fired but later some of them were converted to gas fired. Figure 9a shows the share of energies generated by different types of power plants in 2009. Figure 9b shows the share of public and private installed capacities in 2009. Figure 9c shows the share of public and private generated energies in 2009.

Libya's transmission system was 40031 km long in 2009. It is comprised of 400 kV, 220 kV, 66 kV and 30 kV transmission lines. Libya has interconnections with Egypt and Tunisia. In 2009 Libya imported 70 GWh from Egypt and 46 GWh from Tunisia. Also Libya exported 111 GWh to Egypt in 2009.

Egypt

In Egypt the power market was controlled by state owned Egyptian Electricity Authority (EEA). In July 2000 seeking liberalization in power sector, EEA was converted to a holding company called Egyptian Electricity Holding Company (EEHC). Since July 2001, a series of restructuring steps took place for the affiliated companies, starting by unbundling of the generation, transmission and distribution activities. Now EEHC has sixteen affiliated companies (six generation, nine distributions and one transmission company). EEHC coordinates between the companies as an integrated economic unit. Some Build Own Operate and Transfer (BOOT) projects with East Delta and West Delta generation companies are also contributing in supply of electricity [6] [15]. The functional structure of Egyptian power market is shown in figure 1e.

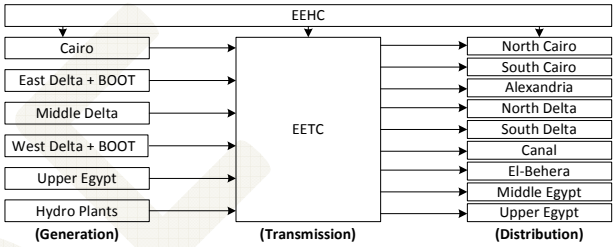

Fig. 1e Egypt-Structure of power market

The peak load demand in 2009 was 21.3 GW that is 8% increase from 2008. The installed capacity in 2009 was 23.5 GW that is 4% increase from 2008. The energy consumed in 2009 was 123.5 TWh that is 6.2% increase from 2008. The energy generated in 2009 was 131 TWh that is 4.7% increase from 2008. The time-series in figure 6a shows the development of installed capacity and peak load demand from 2003-2009. The time-series in figure 6b shows the development in energy generated and consumed from 2003-2009.

Egypt's installed capacity consists of thermal, hydro and wind power plants. Thermal units have more than 80% of total installed capacity. Figure 9a shows the share of energies generated by different types of power plants in Egypt in 2009. In 2009 BOOT projects contributed 10% of total generated energy. Figure 9b shows the share of public and private installed capacities in 2009. Figure 9c shows the share of public and private generated energies 2009.

The total length of Egypt's transmission system in 2009 was 41016 km. It is comprised of 500 kV, 400 kV, 220 kV, 132 kV, 66 kV and 33 kV transmission lines. Egypt has electrical interconnections with Jordan, Libya and Syria (via Libya). In 2009 Egypt exported 638 GWh to Jordan, 70 GWh to Libya and 186 GWh to Syria. Also Egypt imported 13 GWh from Jordan, 111 GWh from Libya and 2 GWh from Syria.

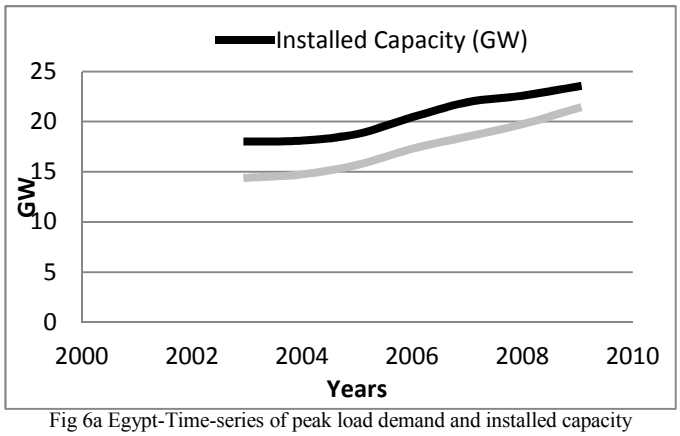

Fig 6a Egypt-Time-series of peak load demand and installed capacity

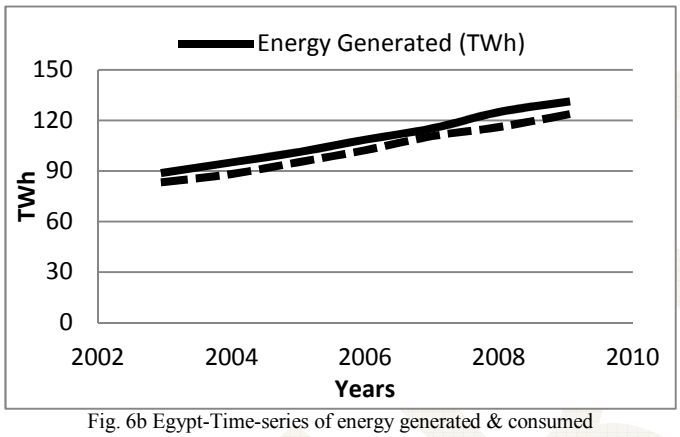

Fig. 6b Egypt-Time-series of energy generated & consumed

Jordan

In 1976 Jordan Electricity Authority (JEA) was established. In 1996 a step towards corporatization converted JEA into National Electric Power Company (NEPCO). In 1999 another restructuring converted NEPCO into three companies, National Electric Power Company (NEPCO) responsible for power transmission, Central Electricity Generation Company (CEGCO) responsible for power generation, Electricity Distribution Company (EDCO) responsible for power distribution. At present EDCO is fully privatized and CEGCO is 60% privatized. The power generation is carried out by CEGCO along with Samra Electric Power Generation Company (SEPGCO) and Independent Power Producers (IPPs). The power distribution is carried out by EDCO along with Irbid District Electricity Company (IDECO) and Jordan Electric Power Company (JEPCO) [7] [8] [9] [15]. The power market operates with a single buyer NEPCO. The functional structure of Jordanian power market is shown in figure 1f.

The peak load demand in 2009 was 2.32 GW that is 2% increase from 2008. The installed capacity in 2009 was 2.74 GW that is 2.9% increase from 2008. The energy consumed in 2009 was 12.5 TWh that is 3.3% increase from 2008. The energy generated in 2009 was 14.2 TWh that is 3% increase from 2008. The time-series in figure 7a shows the development of installed capacity and peak load demand from 2003-2009. The time- series in figure 7b shows the development in energy generated and consumed from 2003-2009.

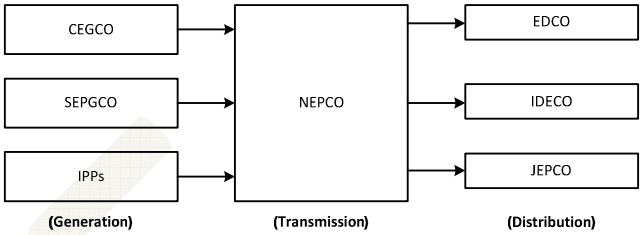

Fig 1f Jordan-Structure of power market

Jordan's installed capacity consists of thermal, hydro, wind and biogas power plants. In 2009 thermal power plants generated 99.5% of total energy. Hydro power plants contributed 0.4%, wind power plants contributed 0.02% and biogas power plants contributed 0.05% of total generated energy. Figure 9a shows the share of energies generated by different types of power plants in 2009. Figure 9b shows the share of public and private installed capacities in 2009. Figure 9c shows the share of public and private generated energies in 2009.

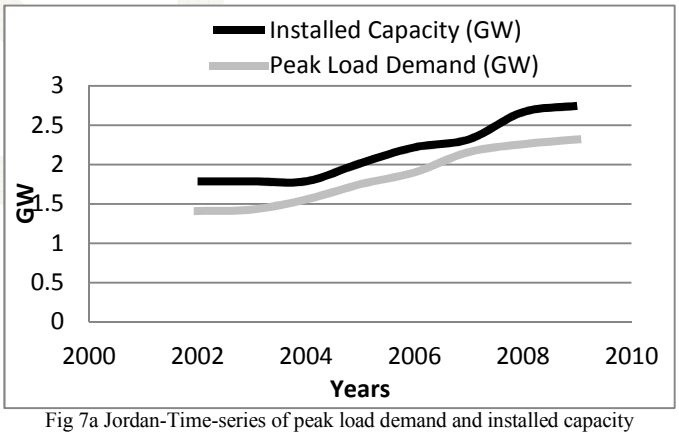

Fig 7a Jordan-Time-series of peak load demand and installed capacity

Jordan has a transmission system of about 4000 km length. It consists of 400 kV, 230 kV, 132 kV and 66 kV transmission lines. Jordan has also underground transmission cables of 71 km long. Jordan has electrical interconnections with Egypt and Syria. In 2009 Jordan exported 9 GWh to Egypt and 68 GWh to Syria. Also in 2009 Jordan imported 362 GWh from Egypt and 20 GWh from Syria.

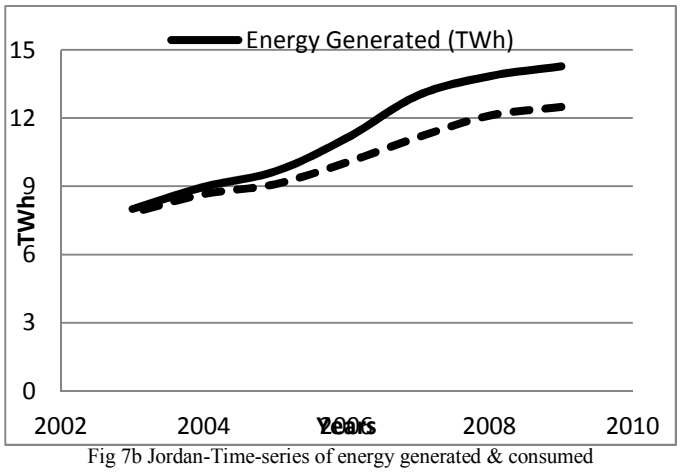

Fig 7b Jordan-Time-series of energy generated & consumed

Turkey

The history of Turkish power market started with state owned Turkish Electricity Authority (TEK) in 1970. In 1993 the state separated TEK into two companies, Generation, Transmission & Trade (TEÄS) and Distribution (TEDÄS). The movement for liberalization of power market was started in 1983 with a law that allowed the participation of private investment in generation sector. In 2001 there was another separation into three companies, Generation (EÜAS), Transmission (TEIÄS) and Trade (TETÄS). In 2005 the privatization process for TEDÄS started. TEDÄS was composed of 21 state owned companies that were operating in 21 regions. The process started with privatization of three companies, BASKENT, AYEDAS and SEDAS. The plan was to privatize all the distribution companies till the end of 2010 [10] [11] [12] [15]. The structure of Turkish power market is shown in figure 1g.

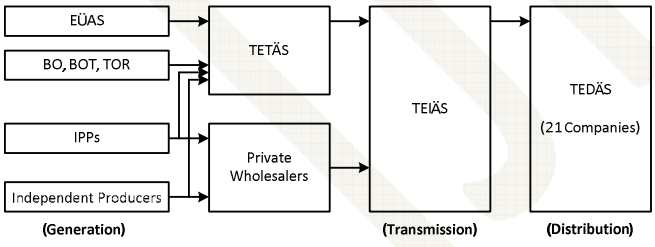

Fig 1g Turkey-Structure of power market

The peak load demand in Turkey in 2009 was 29.6 GW that is 3% decrease from 2008. The installed capacity in 2009 was 44.7 GW that is 7% increase from 2008. The energy consumed in 2009 was 165 TWh that is 3.2 decrease from 2008. The energy generated in 2009 was 194.8 TWh that is 2% decrease from 2008. The time-series in figure 8a shows the development of installed capacity and peak load demand from 2003-2009. The time-series in figure 8b shows the development in energy generated and consumed from 2003-2009.

Turkey's installed capacity consists of thermal, hydro and renewable energy power plants. In 2009 thermal power plants generated 81% of total energy. Hydro power plants contributed 18%, and renewable energy power plants contributed 1% of total generated energy. Figure 9a shows the share of energies generated by different types of power plants in 2009. Figure 9b shows the share of public and private installed capacities in 2009. Figure 9c shows the share of public and private generated energies in 2009.

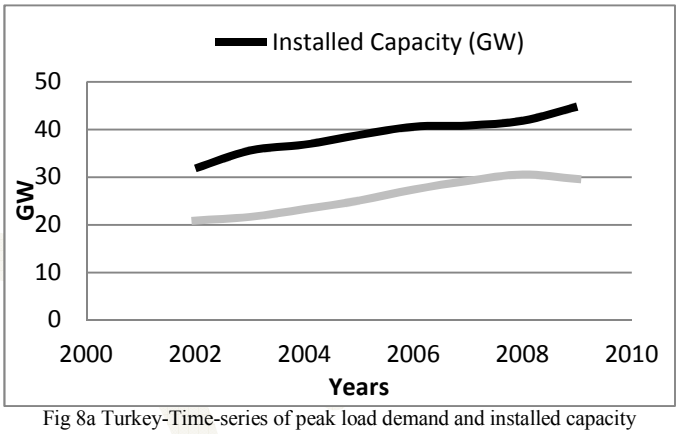

Fig 8a Turkey-Time-series of peak load demand and installed capacity

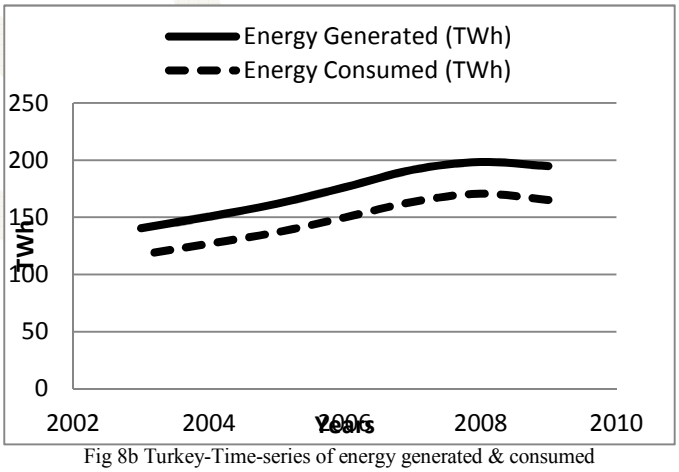

Fig 8b Turkey-Time-series of energy generated & consumed

Turkey had a transmission system of 47147.6 km length in 2009. It is comprised of 380 kV, 220 kV, 154 kV and 66 kV transmission lines. Turkey has electrical interconnections with 8 countries including both European and Asian. The European interconnections include Bulgaria, Greece, Georgia and Armenia. The Asian interconnections include Syria, Iraq, Iran, Azerbaijan and Turkmenistan. In 2009 Turkey exported 662 GWh to Syria, 2430 GWh to Iraq and 0.1 GWh to Azerbaijan. Similarly in 2009 Turkey imported 365 GWh from Georgia, 250 GWh from Azerbaijan and 1009 GWh from Turkmenistan.

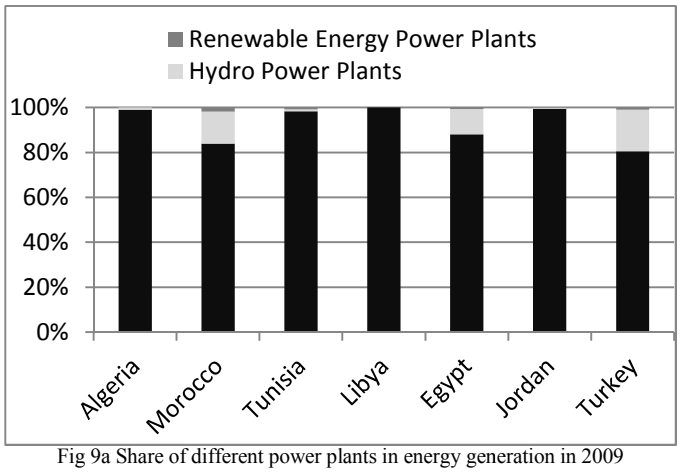

Fig 9a Share of different power plants in energy generation in 2009

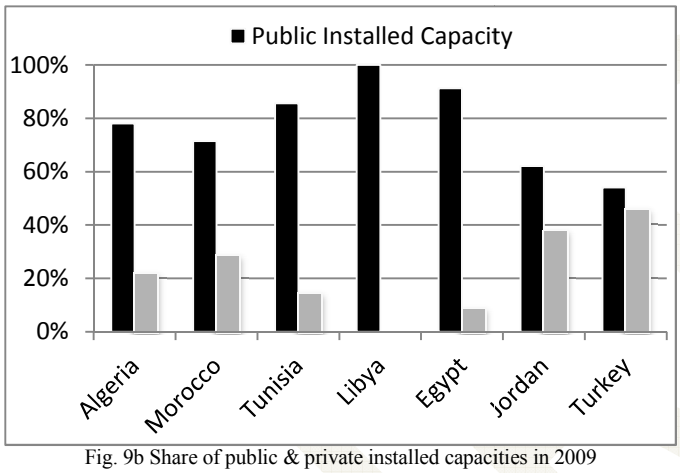

Fig. 9b Share of public & private installed capacities in 2009

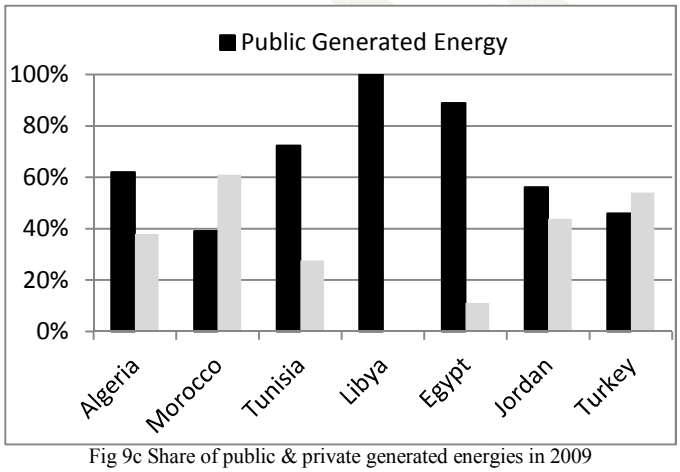

Fig 9c Share of public & private generated energies in 2009

III. EXTRAPOLATION

The existing time-series of energy consumption [12] and peak load demand of the Mediterranean states in focus show a consecutive increase with respect to previous years. An extrapolation of the time series of the aforementioned parameters has been done to develop a rough estimate of their future values. The time series for energy consumption starts from 1970 till 2050 and is shown in figure 10a. The time series for peak load demand starts from 2003 till 2050 and is shown in figure 10b.

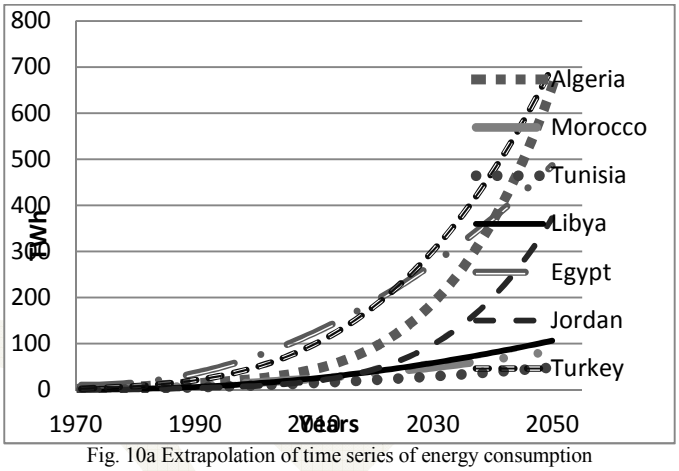

Fig. 10a Extrapolation of time series of energy consumption

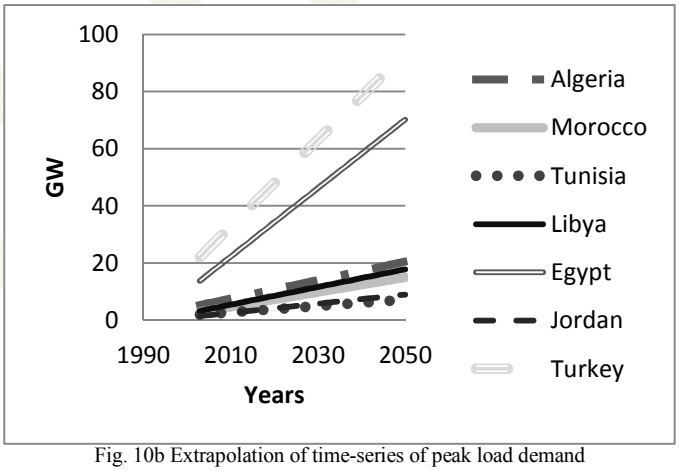

Fig. 10b Extrapolation of time-series of peak load demand

The extrapolation of time-series of energy consumption shows that the collective energy demand in 2050 will be around 2400 TWh. Turkey is on top of the list with 700 TWh, preceded by Algeria and then by Egypt. Tunisia has the lowest energy consumption with 47 TWh. Similarly the extrapolation of time-series of peak load demand results in a collective demand of 233 GW of peak load. Here again Turkey has the highest peak load demand 95 GW, preceded by Egypt and then by Algeria.

IV. CONCLUSIONS

Investigation and analysis of the power markets of Mediterranean states shows that there is a considerable

increase in energy demand over the years with an average rate of increase 9%. The installed capacity has been improved with increase in energy demand with a rate of 17.5%. All countries seem to be self-sufficient to fulfill their energy needs except Morocco.

Thermal power sources fulfill maximum energy needs. Renewable energy sources are also employed in generation but they have a contribution of not more than 2%. Turkey has the highest portion in hydro power generation. Libya has only thermal power generation.

The Turkish power market is the most liberalized in the context of market structure. Libyan power market has no liberalization. The transmission grid is still owned and operated by state for all the Mediterranean states.

In aspect of interconnection of transmission systems, Algeria is connected to Morocco and Tunisia, Tunisia is connected to Libya, Libya is connected to Egypt, Egypt is connected to Jordan, Jordan is connected to Syria, and Syria is connected to Turkey within MENA region. As far as external interconnections are concerned, Morocco is connected to Spain and Turkey is in principle connected to Bulgaria, Greece, Georgia and Armenia within EU-MENA region. A lot of new connections are planned including, Algeria-Spain, Algeria-Italy, Libya-Italy and Tunisia-Italy.

As a whole the Mediterranean states are expected to have significant increase in energy consumption. The 100 GW installed capacity of CSPs will definitely help them to overcome the growing energy needs but they cannot solely rely on this. They must in parallel expand their generation capacity.

References

[1] DESERTEC foundation, www.desertec.org.
[2] SONELGAZ Algeria, Annual Reports 2003-2009
[3] ONE Morocco, Annual Reports 2003-2009
[4] STEG Tunisia, Annual Reports 2003-2009
[5] GECOL Libya Annual Reports 2003-2009
[6] EEHC Egypt, Annual Reports 2003-2009
[7] NEPCO Jordan, Annual Reports 2003.2009
[8] CEGCO. Jordan, http://www.cegco.com.jo/
[9] Dr. Maabreh, Ghalib, Presentation on current and future of electricity in Jordan
[10] Ali Atilgan, A Spotlight on Turkish Electricity Market, Budapest 2009
[11] Report on Privatization of Turkey's Electricity Distribution Companies based on TEIAS and TEDAS data
[12] Turkish Electricity Transmission Company, Electricity Generation & Transmission Statistics 2009, http://www.teias.gov.tr/
[13] World Bank, http://www.worldbank.org/
[14] Steffen Erdle, The DESERTEC Initiative, Powering the development perspectives of Southern Mediterranean countries
[15] http://www.mbendi.com